

## **Origins of the Kuroshio and Mindanao Currents**

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Award Number: N00014-10-0267

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### **LONG-TERM GOALS**

The long-term goal of this project is to quantify the processes leading to the bifurcation of the NEC into the northward flowing Kuroshio and the southward Mindanao Current. As these are the dominant currents of the region, the improved dynamical understanding should lead directly to better predictions.

### **OBJECTIVES**

The four objectives are (a) to clarify the dynamic state of the NEC-Kuroshio-Mindanao Current system, (b) to quantify the temporal evolution of the upper ocean temperature and salinity fields, the seasonal mixed layer above the pycnocline, and the deeper mode and intermediate waters, (c) to evaluate the upper ocean heat, salt and potential vorticity budget in the OKMC region, and (d) to improve the predictability of the oceanic circulation variability on various timescales in the OKMC region by incorporating in-situ data, including those from the profiling float measurements.

### **APPROACH**

Profiling floats will be deployed during the duration of the OKMC project. In conjunction, high-quality satellite altimeter sea surface height (SSH) information will be analyzed. By combining the SSH information and profiling float T/S data, we plan to infer the strengths and locations (through dynamic height difference and maximum gradient) of the incoming NEC and the bifurcated Kuroshio and Mindanao Currents. Dynamic height maps from the SSH and float T/S data will be used to put in perspective the temporal and spatial variability of the regional circulation detected by other observational instruments. The broad-scale SSH information will also be used to explore the dynamics for regional variability that is forced remotely in the interior ocean.

### **WORK COMPLETED**

In collaboration with the Japanese scientists from JAMSTEC, Japan, we have deployed 10 SOLO-II profiling floats in the OKMC domain along ~140°E from 8°N to 18°N. The float deployment was conducted on R/V Mirai between 23-25 August 2011. Nine of the ten floats are functioning normally and are returning high-resolution temperature/salinity data on a 5-day repeat cycle. Analyses of the OKMC float data are being conducted in combination with the coarse-resolution float data from the International Argo Program.

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE <b>30 SEP 2012</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2012 to 00-00-2012</b>	
4. TITLE AND SUBTITLE <b>Origins of the Kuroshio and Mindanao Currents</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>University of Hawaii, Dept of Oceanography, 1000 Pope Rd, Honolulu, HI, 96822</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>3</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

In addition to the float data analyses, we have furthered our investigation into the temporal changes of the North Equatorial Current (NEC) bifurcation and the North Equatorial Countercurrent (NECC) variability with the use of satellite altimeter sea surface height (SSH) data from the past 19 years.

Two peer-reviewed papers are published in Journal of Physical Oceanography and Journal of Geophysical Research, respectively, in 2012.

## **RESULTS**

Our preliminary analyses of the OKMC/Argo profiling floats revealed two well-defined branches of the eastward-flowing subtropical countercurrent (STCC). These two branches, located respectively along 19.0°N and 21.5°N, are embedded within the westward-flowing North Equatorial Current (NEC) between 7°N and 25°N and above the 26.5 isopycnal surface. Below the unventilated 26.5 isopycnal layer, the circulation is dominated by three, eastward-flowing, zonal jets. Dubbed the North Equatorial Undercurrent Jets (NEUJ), these three subthermocline jets are quasi-stationary and persist approximately along 10°N, 13°N and 18°N, respectively. At present, the mean structure and formation mechanism of these newly-observed NEUJs are being explored.

On a broader spatial scale, sea level rise with the trend  $> 10$  mm/yr has been observed in the tropical western Pacific Ocean over the 1993-2009 period. This rate is three times faster than the global mean value of the sea level rise. Analyses of the satellite altimeter data and repeat hydrographic data along 137°E reveal that this regionally enhanced sea level rise is thermosteric in nature and vertically confined to a patch in the upper ocean above the 12°C isotherm. Dynamically, this regional sea level trend is accompanied by southward migration and strengthening of the North Pacific Current (NEC) and North Pacific Countercurrent (NECC). Using a 1.5-layer reduced-gravity model forced by the ECMWF reanalysis wind stress data, the authors find that both the observed sea level rise and the NEC/NECC's southward migrating and strengthening trends are largely attributable to the upper ocean watermass redistribution caused by the surface wind stresses of the recently strengthened atmospheric Walker circulation. Based on the long-term model simulation, it is further found that the observed southward migrating and strengthening trends of the NEC and NECC began in the early 1990s. In the two decades prior to 1993, the NEC and NECC had weakened and migrated northward in response to the decreasing trend in the trade winds across the tropical Pacific Ocean.

## **IMPACT/APPLICATIONS**

It is the first time that the NEC bifurcation, with amplitude exceeding 5 degrees latitude, is captured. This has implications for the forth-coming in-situ observations of the OKMC project, as well as for the ocean processes over the shelf and slope waters off the Philippines and Taiwan that are inherently multi-scaled and pose a challenge to predictability.

The detection of the North Equatorial Undercurrent Jets (NEUJ) is unexpected. Such jets are likely to be important for shear instability in the NEC and are crucial for better understanding of the short-term variability of the NEC.

## **RELATED PROJECTS**

None

## PUBLICATIONS

Qiu, B., and S. Chen, 2010: Interannual-to-decadal variability in the bifurcation of the North Equatorial Current off the Philippines. *J. Phys. Oceanogr.*, **40**, 2525-2538.

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Hsin, Y.-C., and B. Qiu, 2012: Seasonal fluctuations of the surface North Equatorial Countercurrent (NECC) across the Pacific basin. *J. Geophys. Res.*, 117, C06001, doi:10.1029/2011JC007794.